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$$= (\alpha_1 \beta_2 \gamma_3) \begin{vmatrix} \begin{vmatrix} b & c & a_1 \\ d & e & a_2 \\ e & f & a_3 \end{vmatrix} & \begin{vmatrix} a & c & a_1 \\ b & e & a_2 \\ c & f & a_3 \end{vmatrix} & \begin{vmatrix} a & b & a_1 \\ b & d & a_2 \\ c & e & a_3 \end{vmatrix} \\ \begin{vmatrix} b & c & \beta_1 \\ d & e & \beta_2 \\ e & f & \beta_3 \end{vmatrix} & \begin{vmatrix} a & c & \beta_1 \\ b & e & \beta_2 \\ c & f & \beta_3 \end{vmatrix} & \begin{vmatrix} a & b & \beta_1 \\ b & d & \beta_2 \\ c & e & \beta_3 \end{vmatrix} \\ \begin{vmatrix} b & c & \gamma_1 \\ d & e & \gamma_2 \\ e & f & \gamma_3 \end{vmatrix} & \begin{vmatrix} a & c & \gamma_1 \\ b & e & \gamma_2 \\ c & f & \gamma_3 \end{vmatrix} & \begin{vmatrix} a & b & \gamma_1 \\ b & d & \gamma_2 \\ c & e & \gamma_3 \end{vmatrix} \end{vmatrix}$$

Let A, B, C , etc., be the minors with respect to a, b, c , etc. Then

$$\begin{vmatrix} a & b & c \\ b & d & e \\ c & e & f \end{vmatrix}^2 = \begin{vmatrix} A & -B & C \\ -B & D & -E \\ C & -E & F \end{vmatrix}$$

$$\begin{aligned} \therefore \Delta &= (\alpha_1 \beta_2 \gamma_3) \begin{vmatrix} \alpha_1 A - \alpha_2 B + \alpha_3 C, & \alpha_1 B - \alpha_2 D + \alpha_3 E, & \alpha_1 C - \alpha_2 E + \alpha_3 F \\ \beta_1 A - \beta_2 B + \beta_3 C, & \beta_1 B - \beta_2 D + \beta_3 E, & \beta_1 C - \beta_2 E + \beta_3 F \\ \gamma_1 A - \gamma_2 B + \gamma_3 C, & \gamma_1 B - \gamma_2 D + \gamma_3 E, & \gamma_1 C - \gamma_2 E + \gamma_3 F \end{vmatrix} \\ &= - (\alpha_1 \beta_2 \gamma_3)^2 \begin{vmatrix} A & -B & C \\ -B & D & -E \\ C & -E & F \end{vmatrix} = - (\alpha_1 \beta_2 \gamma_3)^2 \begin{vmatrix} a & b & c \\ b & d & e \\ c & e & f \end{vmatrix}^2. \end{aligned}$$

117. Proposed by W. J. GREENSTREET, M. A., Editor of The Mathematical Gazette, Stroud, England.

If $x \cos a + y \cos a = a \cos \theta + b \cos \varphi$, and $x \sin a + b \sin \varphi = y \sin a + a \sin \theta = \kappa$, find the maximum value of κ , and the values of x and y .

Solución by G. B. M. ZERR, A.M., Ph. D., Professor of Chemistry and Physics, The Temple College, Philadelphia, Pa.

$$(x+y) \cos a = a \cos \theta + b \cos \varphi \dots (1).$$

$$(x+y) \sin a + a \sin \theta + b \sin \varphi = 2\kappa \dots (2).$$

(1) in (2) gives

$$\frac{(a \cos \theta + b \cos \varphi) \sin a}{\cos a} + a \sin \theta + b \sin \varphi = 2\kappa, \text{ or}$$

$$a \sin(\theta + a) + b \sin(\varphi + a) - 2\kappa \cos a = 0 = u.$$

$$\therefore du/d\theta = a \cos(\theta + a) = 0, du/d\varphi = b \cos(\varphi + a) = 0.$$

$$\therefore \theta = \varphi = \frac{1}{2}\pi - a \text{ for a maximum.}$$

$$\therefore \kappa = \frac{1}{2}(a+b) \sec a \text{ is the maximum value.}$$

$$x \cos a + \frac{(\kappa - a \sin \theta) \cos a}{\sin a} = a \cos \theta + b \cos \varphi.$$